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Abstract

TEMPERATURE LIMITS AND THE OPTIMISATION OF POWER OUTPUT IN CALDER AND CHAPELCROSS REACTORS

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The operating limits which are specified for various items of plant determine the performance of a power reactor. These limits are designed to ensure safe and satisfactory operation under normal operating conditions and to minimise the possible hazard arising in the event of a fault. The accumulation of data obtained from the reactor during operation reduces the initial uncertainties in fundamental parameters and actual operating conditions for which due allowance must be made in setting the original limits. Thus improvements in reactor performance can be made.

Temperature is one of the most important limiting parameters in determining the performance of fuel elements, moderator and pressure vessel. In addition to the requirement that there should be no impairment of satisfactory behaviour of fuel during irradiation under normal operating conditions, a limitation is imposed by the criterion that there should be a reasonable probability of avoiding the ignition of single channels in the event of the worst credible fault, a depressurisation incident. The calculations and assessment of experimental data which enable the uncertainty of prediction of the complete steady-state temperature distribution to be determined, the calculation of transient rises suffered by each channel, and the application of these calculations and other data to the determination of operating limits are described.

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Limitations on the extent of irradiation damage to graphite, phenomena which are also temperature dependent, can be defined from both operational and safety considerations. The main properties discussed in the paper are growth, stored energy and air-oxidation, the first two being limited by a minimum graphite temperature and the third by a maximum temperature. Growth is monitored by changes in Wigner gap size, the measurements being correlated with dimensional changes produced by irradiating specimens in high flux reactors after correcting the latter results for differences in temperature and dose-rate. A limiting temperature is then set by the criterion that no operational difficulties should arise during the life of the reactor. Stored energy limits are dictated by the criterion that a single channel fire should not spread to other channels. Oxidation of graphite introduces a further heat source into a depressurisation fault when air has been drawn into the reactor, and a maximum temperature is set which takes into account the operative measures which it is reasonable to suppose can be carried out if such an incident occurs.

The temperature limits on the pressure vessel are fixed by necessity to avoid the occurrence of two main phenomena. The first, which governs the minimum temperature, is brittle fracture, and is studied by out-of-pile and in-pile specimen measurements. The second phenomenon is stress rupture, which sets on upper temperature limit so that the time to rupture at the stress levels obtaining in the vessel, making due allowance for relaxation du to creep, will exceed the required life. The results of analysis of stress rupture data from specimens, and the application of this to the particular conditions are described.